DRF-316
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RESEARCH ARTICLE Asian Journal of Dairy and Food Research

Production and Characterization of Cashew Apple Powder

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10.18805/ajdfr.DRF-316

ABSTRACT

Background: This work focused on the valorization of cashew apple, which, when ripe, rot in plantations in Togo despite its richness in vitamin C and other nutrients. The aims were to produce and characterize cashew apple powder.

Methods: In this study, six different of cashew apple powder were made. After the process of picking, sorting, washing, steam bleaching for 15 minutes or not, cutting into rounds, drying at 45-50°C in the oven or in the sun, grinding was carried out. The powders were sealed and stored in polyethylene bags at temperatures between 30 and 32°C. The physico-chemical characteristics were determined by titrimetry and atomic absorption spectrophotometer.

Result: The moisture content of the powders varies from 10 to 11% with a yield ranging from 22.52 to 28.12%. The vitamin C and protein content obtained ranged from 688.7 to 924.5 mg/100 g (12.83 to 15.33%) respectively. The fiber content from 7.48% to 7.83%. Two powders retained a light yellow color more visibly than the other powder which are a little darker.

Key words: Characterization, Cashew apple, Powder, Valorization.

INTRODUCTION

The cashew tree (*Anacardium occidentale*) is a plant of multiple and varied interest. Its native range is South America, specifically the Ceara region of northeastern Brazil where it occurs in large natural stands. Its introduction in Africa was made by the Portuguese Colonists as early as the 16th and 17th centuries. Togo, an agricultural country, has really experienced the extension of cashew plantations in the Central, Kara and Savane regions, in the early 60s; in the form of collective fields thanks to the company TOGOFRUIT. Despite the proliferation of cashew plantations nowadays, in terms of rankings in 2019, Togo is at least cashew nut productor country in the African sub-region behind Côte d'Ivoire, Benin, Ghana, Guinea and Burkina Faso. In recent decades, *Anacardium occidentale* plantations became increasingly important, which also encouraged the creation of the cashew sector in Togo Tebonou *et al*. (2014). Although the cashew apple (CA) is used to make jams, canned syrup, fruit juice, fruit pastes, alcohol, vinegar and others, a large amount of CA is still abandoned to rot in cashew plantations Padonou *et al*. (2016). This is due to the lack of knowledge of the appropriate techniques for its transformation into other by-products Houssou *et al*. (2016). Post-harvest management of tropical fruits in these-countries must be the concern of agri-food technologists because much of the fruits and vegetables in crops rot in fields and on shelves due to lack of conservation or appropriate processing technologies.

To manufacture a product, the availability of sufficient quantities of the raw material is an essential condition. The raw material must be abundant and, above all, cheap (Photo 1). The fake fruit of the CA is very rich in vitamin C, which can be used also in the development of infant flours by local processors. In order to guarantee the full nutritional value of these flours, storage conditions for these semi-finished products should be proposed Moumouni Koala *et al*. (2014).

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How to cite this article: Dansou, X., Ouadja, B. and Baba, G. (2023). Production and Characterization of Cashew Apple Powder. Asian Journal of Dairy and Food Research.doi:10.18805/ajdfr.DRF-316

Submitted: 14-02-2023 **Accepted:** 10-05-2023 **Online:** 26-05-2023

The objective of this work is to produce CA powder and determine its characteristics. It could be adapted in the crop valorization policy to obtain an innovative product, accessible to people around the world. In the production of this powder, the methods of processing and pre-treatment of the raw material and the storage conditions of the powder are important. The final product must not be combined with any chemicals, improved solar pre-drying followed by parboiling drying at 45°C, 50°C will be used to obtain a product of satisfactory quality.

MATERIALS AND METHODS

Plant material

The CA used were harvested at maturity in the plantations in Kara (9°33′03″N and 1°11′09″E) 400 km from Lomé. The most abundant varieties used in this work are red and yellow still very firm. The picked CA were refrigerated in coolers and transported to the laboratory of Kara University for analyses. The geometric quantities considered in the assessment of the morphology of CA in this study are length and width. Dimensions were measured using a caliper using the method of Diakabana *et al*. (2013).

Sample preparation

After sorting the picked fruit, the retained CA were washed, drained, trimmed and weighed. Thus, six samples of the same mass (1000 g±1g) were made.

The fruit divided into two groups was cut into thin slices using a stainless-steel knife. The first group of three samples underwent steam bleaching for 20 minutes and the second group of three samples was not bleached. Of these two groups, six type of CA powder formulations were produced; coded as follows: SSASB (improved solar drying without bleaching); SSAAB (enhanced solar drying preceded by bleaching); PE45SB (apple dried in an oven at 45°C without blanching); PE45AB (apple dried in an oven at 45°C preceded by bleaching); PE50SB (apple steamed at 50°C without blanching); PE50AB (apple parboiled at 50°C with blanching). This work was carried out in the période from January to April 2020 and from January to June 2022 in the Laboratory Organic Chemistry and Environmental Science of Kara University.

The memmert brand Turbo Mixed Hot Forced-Air Electric Dryer was used CA wafers were arranged on spaced bearings to allow air circulation between them. The temperature was set by 45°C and 50°C. Enhanced solar drying was performed on three samples before parboiling following the protocol described by Kameni *et al*. (2003).

After drying, the CA washers were crushed using a Binatone stainless steel knife mill. Subsequently, each sample was sieved through a sieve of mesh 0.1 mm diameter. The resulting powder was immediately sealed in polyethylene bags and stored at laboratory room temperature (30-32°C). The mass of each powder was also taken to determine the yield from equation 1.

$$R= \frac{\text{Weight of powder}}{\text{Weight of fresh fruit}} \times 100 \quad \text{....(1)}$$

Physicochemical analysis of powders

The refractometry solids content was determined using a portable refractometer type K7117 graduated from 0-80 °Brix.

The determination of total sugar was carried out by the phenol-sulfuric colorimetric method Dubois *et al*. (1956). The sample is heated in the presence of concentrated sulfuric acid and 5% of phenol.

5 g of powder were dissolved in 10 mL of distilled water. The mixture was stirred for 30 minutes. The PT-10 probe of the Sartorius pH meter was immersed in the beaker containing the mixture and the pH reading was made after stabilization.

In the determination of dry matter content, five grams of product were weighed in stainless steel cups and then the samples were placed in an oven at 105°C for 24 hours (up to constant weight). The experiment was doubled and equation 2 was used to calculate the dry matter content of the powders.

$$\%\,MS = \frac{W_{\text{after oven}}}{W_{\text{initial}}} \times 100 \quad \text{....(2)}$$

The ash content is determined on the basis of a Narbertherm oven made in Germany (30-3000°C). The sample is incinerated at 550°C for 6 hours. The percentage of ash is calculated from the mass of the residue after incineration. Indeed, a crucible was dried in an oven at 103°C for 1 hour and weighed (m_0). After removal and cooling with a moisture analyzer, 1 g of powder was introduced and the whole was put in the oven at 105°C until the water was removed. The crucible containing the dehydrated sample was weighed (m_s) and put in the oven at 550°C for 6 hours. The crucible was cooled with a moisture analyzer to room temperature and weighed rapidly (m_C). The ash content (TC) was determined from equation 3:

$$TC = \frac{m_c - m_o}{m_s - m_o} \times 100 \quad \text{....(3)}$$

The Kjeldahl method was used for the determination of proteins. A test portion of 0.2 g of powder with the addition of 10 mL of concentrated sulphuric acid and catalysts (3.5 g of K_2SO_4 and 0.4 g of $CuSO_4$) was mineralized at 400°C for 2 hours. The protein content (P) was determined by equation 4.

$$P = \frac{(V_1 - V_0) \times N \times 14 \times 0.001 \times 6.25}{m} \times 100$$

With, ...(4)

V_0 = Volume of H_2SO_4, used to titrate the blank.
V_1 = Volume of H_2SO_4 for the sample.
N = Normality of sulfuric acid.
m = Mass of the sample.
6.25 = Nitrogen-to-protein conversion coefficient.
14 = Molar mass of nitrogen.
0.001= Volume conversion factor (mL) to L.

The lipid content was determined according to the method described by Ogunjobi *et al*. (2010).

For the determination of the Vitamin C content of powder, method used is that using 2-6 dichlorophenol indophenol described. 1 g test portion was weighed and mixed with 5 mL of 10% acetic acid and then adjusted to 50 mL in a volumetric flask with acetic acid solution. The whole is then homogenized and filtered immediately. A volume of 10 mL of this extract is introduced into a beaker and titrated with a solution of 2.6 DCPIP (0.1%) of indophenol until the appearance of the persistent pink color, then the volume A noted. A control dosage is carried out using distilled water instead of the extract to be measured. The results expressed represent the average of four trials. The vitamin C content, expressed in mg/100 g of product, is given by equation 5.

$$Q_c\ (\text{mg}/100\ \text{g}) = \frac{(A - B) \times C \times VT \times 100}{V_i \times S} \quad \text{....(5)}$$

Where,
A = Volume in mL of the 2-6 DCPIP solution.
B = Volume in mL of the indophenol used for the blank.
C = Mass in mg of ascorbic acid equivalent to 1 mL of standard solution.
S = Mass of the test portion.
VT = Total sample volume.
Vi = Volume of the test portion.

The energy value was calculated from equation 6 using Atwater-specific coefficients for protein, fat and carbohydrates. EV (kcal) = [(% Carbohydrates $\times$ 4) + (% Protein 4) + (% Fat 9)] (6) Ogunjobi *et al*. (2010).
Total alimentary fibre were detrmined following the method of Costa *et al*. (2009).

Mineral salt

Mineral salts such as Na, Mg, K, Ca and Fe were determined by the AAS atomic absorption spectrophotometer (iCE 3000 SERIES THERMO FISCHER brand). The methodology used was that of Offia *et al*. (2015).

RESULTS AND DISCUSSION

Plant material

The CA used in this study are red and yellow in color and have no injury. From the morphological analysis, it appears that the length varies from (54.25±0.5; 73.90±0.43) mm, the width and thickness are identical and vary from (38.79±1.53; 48.52±0.52) mm. The morphological characteristics in particular, the length and width of the present study corroborate those of Gbohaïda *et al*. (2015) which range from 60 to 69.9 mm and from 33.55 to 43.42 mm, respectively. However, these values are higher than those found by Marc *et al*. (2012) which vary from 31 to 49 mm. In view of these results, cashew apples from the Kara region seem to be elongated compared to those from Côte d'Ivoire, which are rounded.

The Brix degree (soluble sugar content) of the CA used to produce the powder ranged from 12 to 14 for red apples and from 13 to 15 for yellow apples. The Brix degree depends on the color of the fruit. These values are higher than those found by Hêdiblè *et al*. (2017) whose values varying between 8.2 and 10.2 °Brix. The difference in Brix from fruit juices could be explained by several factors. In particular, the differences between climatic conditions, pedological, the degree of ripeness of the fruits and also by the variety of the fruits. However, the high moisture content of this raw material which is 88.6% is the major constraint for his preservation and could influence the production yield of his powder.

Cashew apple powder obtained

Photo 2 shows the appearance of the different formulations of powder obtained. Depending on the drying conditions, the powders obtained under solar drying conditions differ from those obtained by drying in an oven at 45°C, as well as those obtained in an oven at 50°C. Apples that have undergone bleaching gave slightly lighter powders than those that have not been bleached except for those steamed at 45°C. The colour changes observed in the case of powders from bleached apples may be due to Maillard reactions (non-enzymatic browning) that take place in the products during technological treatments Noguchi *et al*. (1983). Both reactions (enzymatic browning and non-enzymatic) are sources of color change in the case of unbleached apples. The effect of temperature would also be a source of color changes.

The drying temperature 45°C has an impact (slowing effect) on enzymatic and non-enzymatic browning reactions. The powders obtained from apples dried at this temperature have retained much more a color that pulls towards the starting color of fresh apples. The SSASB and

Photo 1: Cashew apples in decay in plantation of Sarakawa (Togo) after cashew nut harvest.

Photo 2: Appearance of CA powders.

SSAAS formulations have a slightly darker color. This could be due to temperature variations during drying especially during the night.

Physico-chemical characteristics of powders

Table 1 presents the results of physico-chemical and compositional analyses obtained from CA powders. It summarizes the contents of water, ash, protein, carbohydrates, fiber, vitamin C, density and hydrogen potential. These values are the two-year average.

The moisture content of the different types of powder formulations ranged from 10 to 11. According to the Network Bulletin, May 1998, in the case of infant flours, a humidity of less than 8% is recommended. This humidity level is high compared to this standard and cannot promote long-term preservation. This humidity level could be related to the drying temperature and the efficiency of the dryer or climatic conditions. The work of Dos *et al*. (2012) gave a humidity of 9.29% in the context of CA bagasse powders. A low humidity such as that of Uchoa *et al*. (2009) which is 6.52% is in the value range that guarantees long-term storage.

The pH values of the different powders were less than 4.5; therefore, the fake fruit from which the powder is derived was considered an acidic food product Costa *et al*. (2009). The acidity values found offer great stability, which can make it difficult for microorganisms to grow. However, these pH values are lower than the one found by Ogunjobi *et al*. (2010) which was 4.72.

The determination of ash in practice provides information on the solid mineral part of a sample as opposed to its organic part. It is commonly used for food quality control. The standard recommends an ash content of less than 3. Thus, the analysis of Table 1 shows that the ash content of the powders varied from 2.19 to 2.33. This meets the standard. A higher ash content than our study 2.70 was obtained by Ogunjobi *et al*. (2010). a lower value than our study 1.42 was obtained by Costa *et al*. (2009). The ash contents observed testify upstream to a richness of flours in mineral salts essential for nutrition. This testifies that CA powder would improve the mineral content of composite flours or the composition of dietary supplement foods.

The protein contents of the different powder formulations according to Table 1 vary from 12.83 to 15.33%. This content is higher than the protein content of wheat flour and sweet potato which are respectively 11.9 and 3.2% according to the work of Ndangui, (2015). The work of Costa *et al*. (2009) and Ogunjobi *et al*. (2010) gave a lower protein content of 7.63 and 12.75% respectively in CA powders. The protein content of CA powder could make it possible to compensate for the protein deficit of sweet potato flour or any other flour for the purpose of combining flours in the realization of a dietary supplement.

Dietary fiber, although naturally occurring, is predominantly derived from plants and carbohydrate in nature and can play a major role in the body's metabolism as a potential source of energy metabolites Zeanandin *et al*. (2011). The fiber content in accordance with Table 1 varies from 7.48 % to 7.83%. These values are significantly higher than that found by Ogunjobi *et al*. (2010) and Offia *et al*. (2015) 4.08 and 6.25 respectively in Nigeria. The type of soil, climate and study period could also significantly influence the results obtained. Dietary fiber facilitates bowel movements and prevents many gastrointestinal diseases Offia *et al*. (2015).

The carbohydrate content of powders varies between 61.15 and 63.59% (Table 1). These contents are high compared to the results of Duarte *et al*. (2017) which is 44.5% and slightly low compared to those of Offia *et al*. (2015) which is 77.95%. Indeed, the higher the protein, lipid and ash content, the less carbohydrate there is. However, the values found in our study corroborate those found by Ogunjobi *et al*. (2010) and Dos *et al*. (2012) which were 68.60% and 69.4% respectively.

The lipid content shown in Table 1 ranges from 3.14% to 3.54%. These levels are higher than that found by Duarte *et al*. (2017) which is 2.15. However, those in our study are very close to 3.70 found by Costa *et al*. (2009).

The bulk density ranged from 0.62 to 0.66. A density of 0.63 was found by Offia *et al*. (2015). It is low compared to the result of the same author in the case of wheat flour (0.88). According to this author, 0.63 is the best density in breakfast food preparation and infant food formulation.

Table 1: Physicochemical characteristics of CA powder.

Para-meters	Characteristics of different types of powders					
	SSASB	SSAAB	PE45SB	PE45AB	PE50SB	PE50AB
%H	10.23±0.11	10.3±0.17	10.11±0.19	11.34±0.16	10.2±0.14	10.25±0.14
%T	2.32±0.01	2.32±0.03	2.24±0.07	2.22±0.02	2.19±0.01	2.33±0.04
%P	15.33±0.04	13.2±0.09	14.38±0.10	13.3±0.05	13.5±0.1	12.83±0.11
%L	3.14±0.15	3.54±0.12	3.48±0.18	3.35±0.16	3.42±0.13	3.24±0.09
%GL	61.15±0.34	63.16±0.32	62.27±0.21	62.12±0.18	63.06±0.25	63.59±0.23
%FT	7.83±0.17	7.48±0.09	7.52±0.11	7.65±0.06	7.58±0.1	7.76±0.12
pH	3.96±0.02	4.32±0.08	4.11±0.03	4.22±0.08	4.32±0.05	4.28±0.04
d	0.64±0.11	0.66±0.13	0.63±0.18	0.63±0.14	0.62±0.12	0.62±0.14

% H: Humidity; %T: Ash content; %P: Protein content; % L: Lipids; % ST: Total sugar content; % FT: Total fiber, % GL: Carbohydrates; d (kg/m^3): Density.

Table 2: Characteristics energy value of vitamin C and production yield of PC powder.

Types of powders	Parameters		
	VC (mg/100 g)	EV kcal/100 g	R (%)
PE50SB	924.5±0.08	337.22±0.49	22.51±0.54
PE50AB	894.2±0.05	334.84±0.68	24.17±0.72
PE45AB	860.5±0.01	331.91±0.64	24.18±0.30
PE45SB	838.4±0.06	337.92±0.67	23.32±0.50
SSASB	694.4±0.03	334.18±0.43	27.32±0.71
SSAAB	688.7±0.01	337.31±0.85	27.12±0.60

VC: Vitamin C; EV: Energy value; R: Yield.

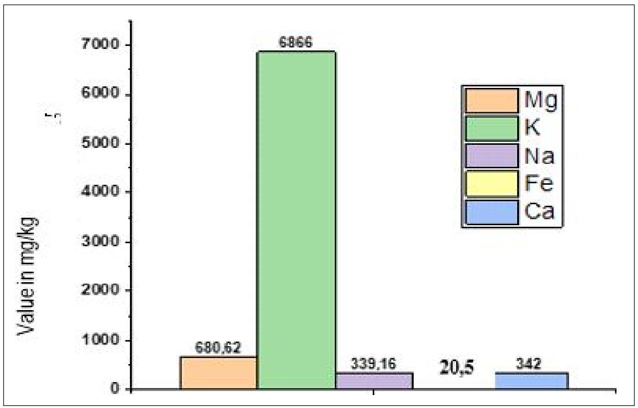

Fig 1: Mineral salt composition of CA powder.

Energy and vitamin C characteristics

Table 2 summarizes the vitamin C content, energy value and production yield of CA powders.

Fruit is an excellent source of vitamin C. The different types of formulation reveal a significant amount of vitamin C according to Table 2. The formulations PE50SB, PE50AB, PE45AB, PE45SB, SSASB, SSAAB powder have in descending order amounts of vitamin C respectively (924.5, 894.2; 860.5; 838.4; 694.4; 688.7 mg/100 g). Whitening has a significant effect on vitamin C loss. Low levels of 52.60 and 42.82 mg/100 g were observed respectively in the work of Ogunjobi *et al*. (2010) and Offia *et al*. (2015). This could be explained by the effect of temperature during bleaching or the volatility of vitamin C during drying.

The energy value of CA powders ranges from 331.91 to 337.92 Kcal/100 g. This richness in energy value can be explained by a significant part of carbohydrates. These energy values are slightly close to those of infant flours studied in the work of Sanou *et al*. (2017) and which varied from 381.1 to 411.3 Kcal/100 g. The consumption of CA powder alone or as a substitute for other flours would be very beneficial in calorie.

The low production yield of powders 22.5-27.32% (w/w) (Table 2) is the consequence of a high humidity of the cashew apple 88.6% which is one of the difficulties in transport. The moisture content of the powders does not correlate with the production yield. Normally, the wetter the powder, the higher the yield. This is not the case in our study because SSASB and PE45AB with humidity 10.23 and 11.34 respectively have yields of 27.32 and 24.18. This is explained by losses during grinding (residues) and sieving.

Mineral salts

Fig 1 shows the nutritional value in mineral salts of the powders produced. From the analysis of the results, it appears that the powders analyzed are rich in mineral salts, including potassium 6866 mg/kg, magnesium 680.62 mg/kg, sodium 339.16 mg/kg, calcium 342 mg/kg and iron 20.5 mg/kg. The high ash content (Table 1) confirms the presence of large quantities of mineral salts. A higher calcium and iron content than that of our work respectively 8000 and 40 mg/kg was found by Offia *et al*. (2015). But this very high calcium value would probably be due to the treatment of apples with calcium chloride. This same author found a sodium content 60 mg/kg lower than that of our study. This difference can be explained either by the nature of the soils. Since the powder is rich in Ca, Mg and K, it can be used in human food.

CONCLUSION

During this study, different CA powders were produced. Conventional chemical analysis techniques were used for its characterization. This study shows that temperature and bleaching have an effect on the colour of the powders produced. They are rich in protein (12.83 to 15.33%), total fiber (7.48 to 7.83%), vitamin C (688.7 to 924.5 mg/100 g), minerals such as (calcium 342 mg/kg; magnesium 680.62 mg/kg and potassium 6868 mg/kg). Our results indicate that, the proposal to produce CA powder is a means of recovery of this raw material that rots in plantations. This could be adapted in the crop valorization policy to obtain innovative products accessible to populations and capable of being incorporated in human food. Nevertheless, an analysis of anti-nutritional factors will be the subject of our next studies.

Conflict of interest: None.

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